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DISCONTINUITIES IN NATURE'S METHODS.

BY HENRY H. BATES.

The ingenious analogy drawn by Mr. Babbage, in the ninth Bridgewater treatise, from the operations of his calculating machine, to enforce an argument in favor of the conceivability of miracle, by bringing it under the domain of law, has far more of pertinency to illustrate some of the methods of evolution. Discontinuities in the cosmical world are termed catastrophic, and no one doubts that they occur, or that they are under the dominion of law. As not within my present theme I pass over these, as well as that great discontinuity involved in the passage from the inorganic to the organic kingdom, which we also infer to have taken place under operations of law, not yet fully understood; also such apparent discontinuities as the passage from invertebrate to vertebrate life, or from implacental to placental life; with the observation that whenever nature seems to have carried specialization to its fullest extent, and to have exhausted the possibilities by mere differentiation on a certain plan, as of molluscan structure, for example, in its highest type the cuttle-fish, or of articulate structure in the honey-bee, she is found to have laid the foundation for a new differentiation, and a new specialization, with higher possibilities, from a different stem low down in the scale, constituting in its results an apparent discontinuity, on account of the obscurity, and feebleness, and instability of the first unspecialized departures, by which they have been mostly either unobserved or early obliterated through the operation of competition.

Passing over the wide domain of biology, which affords so many instances of this complexity of natural action, illustrations of the same law may be found in the domain of anthropology. The advent of Man, and his means of advancement, afford such examples. The development of the inventive faculty, as the distinguishing characteristic of mind, caused a modification of the old plan of progress by selective extermination, as has been pointed out by Mr. Ward. Instead of being himself modified by nature, as hitherto, man began to act upon nature, both organic and inorganic, as a

modifier. Henceforth, natural selection affected only mental and ethnic qualities, through modification of his nervous structure. Instead of developing specialized organs, he began to construct extraneous ones for his use, having arrived at the specialized hand, by which such a new departure became possible. The discontinuity which especially characterizes man's development after this stage is this mental in place of physical evolution, coupled with evolution by extraneous organs, as it is my object to point out.

To illustrate. The lower animals exhibit constructive faculties in some instances comparable to those of man. Take the beaver for instance. As a natural builder and engineer his judgment and skill are excellent and wonderful. But the development of these faculties in him resulted only in the modification of his physical structure, by the old and slow process of natural selection. He developed cutting tools at one end and a trowel at the other, and the limit of progress was attained. The feline carnivora, type of the militant principle, evolved highly efficient weapons at all extremities, and the lion became the king of beasts. He could not be defeated or excelled in his own line of evolution. The social insects display marvelous faculties for industrial organization, but they have not developed into tool-using animals. They even modify nature to their advantage, as does the beaver, but it is to an infinitesimal degree only. Nature has signally modified *them*, for caste purposes, by the old principle of natural selection, and they did not reach a stage of development where they could turn the tables and assume control of nature's blind forces. Not only in respect of size, but plan of structure, they became too highly specialized low down in the series.

For man, however, there was a long, unobtrusive preparation. Fostered by a mild climate, abundant food, and an arboreal retreat, with social and inquisitive instincts, the germs of many faculties were simultaneously founded, in a physique of efficient bulk and considerable longevity, without which no high individual development is possible. The cause of the first human differentiations is of course veiled in obscurity, as is the whole subject of variation. Among efficient causes recognized are secular changes of environment, extensive migrations from old habitats into new conditions, and the stress of failure of the customary sources of food supply. Essential variation of species, like the birth of genius, may rise to

the rank of a discontinuity. Suffice it to say, man was born, and took up his role of conqueror.

The earliest of these extraneous organs was the weapon, for the militant necessarily precedes the industrial stage. The evolution of the weapon from the primitive club found in the forest, or the boulder picked up on occasion, has already been traced in former papers before this society. Such a notable acquisition by man enormously increased his power of modifying nature, and especially organic nature. It made him lord of his fellow-creatures by conquering competition. It also introduced the most merciless selection of his own species. Nearly or quite all of the so-called connecting links between himself and his fellow-creatures have been long since exterminated. Militancy ensued, as the earliest type of society, and high specialization followed, through its selective agency, with migration into new surroundings, and consequent differentiation. Certain low arts and industries germinated, and the tool making and using faculty took its growth. Along with this progress language was developing, which enabled the results achieved to be conserved to a much greater extent than by the old and wasteful process of heredity.

But although man was at all times a social animal, industrial organization could not speedily become his predominant characteristic, on account of the precedence of militancy, which is wasteful and suppressive of industry, and its products. Militarism itself, however, by a species of evolution, prepared the way for industrialism of a certain kind. The practice of the warlike arts led to social differentiation, and to caste classification, by the subordination of inferior tribes and members, no longer formidable, instead of their extermination. Among these protected and subdued peoples the rudimentary arts took root and grew. The leisure, also, conquered for the dominant races at such stage, promoted intellectual progress in polite arts and the arts of peace. The minstrel or bard appeared, whence literature arose, as a chronicle of feats of arms and of personal prowess, and by recording tradition created mythologic lore. The institution of literature was a developing agent of enormous power in itself. The rise of imagination, combined with the growing sense of prevalent injustice, had already produced the druid and the prophet. Religion, the first outcome of the ideal, originated the germ of the aesthetic arts.

Such primitive industrialism as could flourish under these con-

ditions, however, was by its nature merely sporadic, continually swept away, and therefore incapable of the highest development. Valor and personal prowess alone were in esteem, and all other qualities existed by sufferance only. This offers a dead lock to progress, at its perfected stage. Military caste is suicidal by nature. As soon as the conservative force of danger and high training relaxes, vicious indulgence and belligerent habits operate with destructive force. The highly evolved military races of history were self-exterminated, not destroyed. Specialization having reached its highest mark through the operation of mere differentiation, a new departure was to be looked for, and as usual, low down on the stem, it was through the humbler elements of society that it occurred. If the invincible power of militancy was to be broken, it could only be by a triumph over mere force parallel to that by which man himself first overcame the lion—the triumph of art and intellection over specialized power of organism.

Militancy had paralyzed man's progress and faculties in Europe for over a thousand years after the wreck of the old military civilizations, before a glimmer of hope appeared. At length, during those dark ages of stagnation and decadence, the asylums of refuge afforded through the superstitions of men to merit other than military, in the monasteries, developed here and there sporadic germs of a new faculty, repeatedly destroyed, but destined eventually to germinate and bear fruit, notwithstanding the adverse and destructive condition of celibacy which constantly neutralized its evolutionary value. The inventive faculties of man, freed from the exigencies both of self-protection and of slavish toil, worked out emancipation by a departure resulting in a true discontinuity, and a new evolutionary progress. The most potent of these agencies was the invention or re-discovery of gunpowder; not, as might have been expected, by one of the militant chiefs, but by a man of peace in his cell. Its gradual introduction abolished the overshadowing importance of personal prowess in arms, equalized the powers of offence and resistance, and gave a foothold for industrial organization, also powerfully promoted by the succeeding invention of printing. The inventive faculties, thus both emancipated and stimulated by these great discoveries, set out upon a new career of development not before paralleled. Modern progress has been exclusively through the development of the arts of peace, of which modern military science is one and not the least. The tool-using and tool-producing power came into

prominence, and has been carried to a marvelous stage of development. The peaceful arts at length prevailed, man's condition became ameliorated, and a new progress has supervened.

The true modification of nature to man's uses can only be held to have commenced at this stage. True, man has in all ages powerfully reacted upon nature by his presence, but mainly to his cost. As Byron says, "Man marks the earth with ruin." From the dawn of history his march meant desolation. Assyria, Persia, Egypt, Phœnicia, Palestine, Greece, are naught but names. These, his most favored and fertile seats of empire—once the gardens of the world—have become deserts through his ravages, largely through denudation by fire and the axe, but also by exhaustion of fertility through ignorance, and misgovernment under military systems. Man has done nothing as yet to reclaim these ancient seats of population, for it takes ages to replace the work of years; but the inventions due to industrialism have now enabled him to move into new, fertile, and primeval regions, and spread over them with unparalleled activity. Improved means of locomotion is the chief of these. Roads, vehicles, and boats heretofore existed commensurate with the commerce of ancient times, but migration was slow and feeble, and fraught with danger. Modern locomotion is a true discontinuity in natural phenomena, judged by its results. If a disinterested intelligence could view our planet from a distant stage, who had formerly observed it in the age of the dinosaur and the plesiosaur, as they then roamed the earth and ravaged the sea, he might indeed regard the scene as not so much changed, but he would behold a new type, which in view of the discontinuity, he might truly marvel over, as a problem of evolution. He would see enormous crawling trains, shrieking and traversing in every direction over fixed trails, and huge mailed hulks saluting and encountering upon the seas. But on a careful scrutiny how different the means of locomotion. By what process of evolution, or modification of plan could so diverse a principle of structure enter? Only by the intervention of the creative brain of man. But by this intervention a new mode of structure and function, and of utilizing a planet, became possible.

These means of locomotion are true extraneous organs. By extraneous organs, in the infancy of invention, man pursued the elk over treacherous snows, and the seal into inhospitable fastnesses. Man alone, of all the higher organisms, has thus conjoined alien organs with his structure. The hermit crab, as weak and defence-

less naturally as man, borrows and utilizes a protective shell, but has become modified to its use. Man has no fur, armor, or natural weapons, but he borrows the pelt and coat of his victims, constructs a defensive armor like that of the turtle or armadillo, bristles with terrible weapons, and in raiment rivals the ornamental decoration of the peacock and bird of paradise, for similar purposes of sexual selection—a selection, however, wholly psychic, since the plumage is borrowed, or fabricated. Among the Hellenic variety he at one period began to cultivate and develop beauty of form and limb by selection and heredity, but all other varieties of the human race attain a more economic satisfaction of the love of the beautiful by external adornment. Here also the inventive faculty by a retrograde step superseded the old selective process, which required a world with better conditions than ours for its full play in that direction. The exigencies of climate gave the ingenious arts predominance, and favored the rising preponderance of psychic over physical selection. Never since has physical excellence been pursued and worshipped as by instinct and passion, but at the best has obtained indirect homage through the efforts of art to rival and neutralize its advantages. This psychic selection, in conjunction with art, has originated a persistent ideal of the human form, in one sex at least, totally at variance with nature, or any natural function, only paralleled in some of the tropic birds.

To revert to the monster artificial organisms before alluded to as characteristic of the world's present era of development. Man does not *inhabit* them, as the hermit crab inhabits his foreign shell. He uses them parasitically, as a means of locomotion. Here also is a new departure. Witness the entire originality of the mechanism of propulsion. A new principle had to be discovered, introduced, and employed. The marvelous complexity of vital mechanics rendered hopeless all attempts at understanding or imitating it. It represents the last stages of a system of mechanics perfected from eternity. A discontinuity—a new beginning—was absolutely necessary to fresh results.

The invention of the wheel is man's creation. It is not found in the mechanics of nature. All the movements of animal machinery are necessarily reciprocating. This does not positively involve a waste of energy in vital mechanics, since nerve impulses and discharges are always a factor in such movements, and these are intermittent, and require alternations of recovery and relaxation. The

keeping up of the lines of nutrition and repair also necessitates a positive material connection, precluding that continuous revolution in one direction which is characteristic of rotary mechanics. Animal mechanism is admirable in its simple adaptation to direct ends and conservation of effort. The fish's tail is a most perfect mechanical propeller, the force being wholly utilized. We can imitate it only by rotary construction. The bird's pair of wings we cannot successfully imitate, though they constitute a most simple solution of an exceedingly complex problem. All of our machines which involve reciprocating parts involve consequent loss of energy by destruction of momentum due to constant changes of direction, but by the device of rotary movements and balanced momenta we obviate this loss, and the loss of time due to recovery of position. The rolling support of a railroad train is far superior, mechanically, to the rise and fall exhibited in an animal's progressive movement, and we could not secure successful locomotion on the latter terms. We even improve our own locomotive powers greatly by introducing a rolling support which shall conserve rectilinear momentum, antagonize gravity, and economize power for propulsion purely. All this development of locomotive powers, could not, so far as we can see, have resulted out of any possible evolution by natural selection. Yet all possible modes of locomotion which employ reciprocating movements have already been evolved and reduced to perfect practice by nature through this principle of variation and selection; all of them admirable, and most of them wonderfully efficient for the purpose, as witness that most artificial mode of propulsion adopted by the sepia, or cephalopod; a simple reaction force-pump, working on hydraulic principles. It remained for nature, having exhausted reciprocatory mechanics, to seek out a means for utilizing the principles of rotary movements, and she solved the problem through preliminary development of the brain of man.

This new mode of course excludes reproduction by generation, but so far as results go this is immaterial. A locomotive or a steamship has a lifetime of its own comparable in duration to that of a sentient organism of parallel importance. Viewing it as an organism the changed mode of reproduction is a discontinuity. Natural selection by competition is not affected by it. Its brain is sentient—the guiding man—and this suffices for its care and safety and repair and exercise of function. This new field of activity for the sentient portion of the organism, so called, reacts on the same, positively

contributing again to a new form of evolution; the evolution of mental faculties competent to originate, construct, repair, reproduce, improve, direct, and utilize these monster creations, otherwise without cause for being. This is a new discontinuity in psychologic development.

By such modes of development a brain out of all proportion to the natural ministering organs has been evolved. No animal evolution presents a parallel solution. It may be peculiar to this planet and unique in the universe. And it is not alone by his extraneous organs for attack and destruction, by extraneous covering, and means of locomotion, that man is distinguished. Look at his supplementary organs of special sense—his telescopic eye, for piercing the depths of infinity—his microscopic eye, for analyzing the infinitesimal—his telephonic ear, for omnipresent perception. Then his power of emotional expression through artificial phonic organs—namely, instruments of music, for producing ideal harmonies. All these magnified means of action, perception, and expression react upon the sentient organism, enhancing and cultivating its already exaggerated powers. They also contribute to its longevity. The human brain is disproportionate to its ministering organs in enduring quality. It goes down to the grave youthful and unimpaired when the latter are worn out. Yet by the help of extraneous adjuvants its useful term is sensibly reinforced and prolonged. Its independence is humorously illustrated in the well known anecdote of the battered veteran, who, on newly arriving at his room in an East Indian inn, kicked off his right leg, detached an arm, deposited one eye in a glass of water, removed his upper and lower teeth, handed his wig to the astonished coolie in attendance, and finally “stampeded” him outright by motioning the half paralyzed wretch to unscrew his head.

In another way has this disproportioned organ become dependent on adventitious aid by its own separate evolution. The nutrimental supply for its relatively large destructive use of cell life offered a problem beyond the power of the old form of selection to solve. Whence could be derived the enormous digestive function to assimilate sufficient nutriment, to say nothing of the time required for its discovery, collection, and consumption? The invention of producing new varieties of highly nutritious food and of their artificial preparation by the art of cookery furnished the solution. Substances wholly unassimilable by man's natural organs are thus

converted into his most available pabulum and utilized by relegating the preliminary stages of the breaking down of organic cell material to the efficient treatment of the culinary art. This artifice many times multiplied man's aggressive efficiency from the first, and no other animal has ascended to it in any degree, though many have become supplied with natural digestive powers far transcending those of man. It constituted an entire departure from improvement by survival of the fittest, and reconciled the otherwise impossible co-existence of great assimilation with moderate assimilative organs and a free and active brain. By thus emancipating and at the same time reinforcing nerve power it gave it intellectual objects of encounter in place of the mere food seeking and assimilating ends which had been the engrossing objects of animal existence hitherto. These liberated faculties when left free to play by the attainment of leisure and the amelioration of conflict, took up the role of the evolution of art—the arts of the beautiful, which record and stimulate the ideal, and thus elevate and refine man and differentiate him still more from his fellow creatures, and the arts of the useful, which minister to his comfort, health, and progress in power over nature and over disorder. I mention the aesthetic arts first, for in all except the arts of barest necessity they uniformly precede the industrial arts in order of development. The colored boy, who "could do without shoes well enough, but was suffering for a breast-pin" was a rude but true type of the evolution of his race.

Mechanical science in the modern sense was unknown to the ancients. Sporadic traces of it appear, among the priestly or leisurely class, but it was confined to clumsy means of deception, and ranked with magic. The corresponding faculties of the brain were brought to the acme of cultivation by the Greeks in the production of the beautiful creations of statical art. Statical mathematics, under the name of geometry, they developed with great precision and insight. Form they fully understood, but no faculty existed in the brain responsive to the laws of kinetics and dynamics. Even the first law of motion, its persistence, was unknown to them, and the most characteristic property of matter, inertia, seems to have been unperceived, though constantly experienced and availed of. Movement was associated with life. The apprehension of the arithmetic of motion, and the faculty of conceiving and organizing machines to execute any desired combination of movements are now instinctive and inherent in the highest specimens of all the modern civilized

European races and their descendants, though not to any extent elsewhere.

Accompanying the industrial evolution of society there has been some corresponding moral improvement, for as Spencer has shown, ethics are indispensable to the social condition. There is nothing, however, inherently elevating to morals in industrialism, nor have individuals attained to any higher practice or theory than did individuals among the ancients. It seems doubtful whether any positive ethical evolution of brain structure has occurred within the historic period, when we note the lofty eminence reached by men of mark from the earliest recorded times, though some effect ought to have and doubtless has resulted on the mass from selective causes alone, through the extermination of criminals, and often of their whole families, for thousands of years. With the disappearance of its urgent necessity this source of progress has ceased. Some sentiments appear to have been intensified by mere growth of sympathy, as that of the brotherhood of man, and the kinship of all living creatures. A love of sylvan scenery is something we find but slight traces of in ancient literature. It is even yet but feebly developed, as a genuine emotion, and certainly does not prevail to the extent to cause man to modify nature in the direction of the aesthetic. He finds "pleasure in the pathless woods," but he hews them ruthlessly down all the same. A Spaniard or an Arab is said to "hate a tree," and each has succeeded in greatly reducing the ancient habitability of his domain. The American backwoodsman is accomplishing the same result, in the same spirit. Still less has man reached that ethical development to cause him to plant for posterity, and unfortunately man's life span is less than that of a tree. The plants upon which he now depends are annuals, and the culture of these leaves no trace of permanent improvement upon the globe, but on the contrary exhaustion. Neither is there any conservation of his fellow creatures; the barbaric hunter's instinct, and the cruelty of "sport" still persisting among the most advanced races. If moral and ethical development have not made a parallel advance with man's improvement in creative faculty within the historical period, the reason must be looked for in the lack hitherto of any positive discovery in that field commensurate with the important discoveries which have promoted his intellectual progress. Such a discovery would afford by its results a crowning instance of a true and beneficent discontinuity, but no moving cause for such evolution beyond the inadequate one of

the bare necessities of association has ever been made out. The want has always been profoundly recognized, and many theories have flourished which have no doubt accomplished great temporary results, but have eventually languished and become sterilized for want of strict confirmation. In this respect the development of the social insects has proceeded quite differently: they seeming to have solved for their purposes the problems both of government and of social ethics. Their plan is caste differentiation, which has wholly failed with us.

Amid this discontinuous or divergent psychic evolution there is a dissonant note. Man's great achievements are always far outstripped by his still greater aspirations. In the free animal world at any period we see nothing but harmonious action and complete fulfillment of function, which is the definition of happiness. The smaller and lower organisms are constantly absorbed and integrated into higher ones, and thus promoted to a higher plane of existence and function by transmigration and recolonization, with a minimum of pain and annihilation of cell-life, and no anticipation or retrospection. Reproduction keeps up a maximum supply of life, and competition furnishes full activity for all faculties. Misery is a psychic quality. Its introduction seems abnormal. Discontent, while a prime factor of human progress, ought to be, but is not, a vanishing factor. These elements of ripeness and decay may indicate the natural limitations of the series. Civilization may be a florescence as fleeting as it is miraculous, costly, and complex. The possibilities of psychic evolution cannot of course be foreseen, but it is well understood that nature's methods are not always and necessarily modes of advance. Even the material conditions of prosperity are by no means stable or continuous. Nature is not optimistic. Degradation and dissolution are involved in evolution. The sage-brush of the plains is no less the product of circumstances than the giant cedar of the Sierras. Geological history is full of evidences of discontinuities which were disastrous to whole races of living beings. We know not when, at any time, some enormous outpouring of mephitic gases from the earth's interior, or some cosmical cloud of noxious dust from outer space, may invade our atmosphere to change its vital character for our purposes. Our limited experience of solar radiation is in favor of its uniformity, but no one can say that a rise or fall of twenty-five or thirty degrees of mean annual temperature is an impossibility; and this would mean momentous consequences to

man and his activities. We chance to be now in the middle period of one of earth's great cosmical summers—that is why we have a history—but should man ever be upon earth at the beginning of one of her cosmical winters, his struggle with nature for existence would be no less severe than that of the animal tribes of the past when overtaken by a glacial period. Man could not, like the carnivora, take to the warm ocean, and live upon fish, and undergo modification and adaptation of structure to such a changed life, as have the sea lions. Nor would such be the normal course of development in his case, he having passed the stage where modification of structure by natural selection is necessary to survival. He would only modify his extraneous organs and his mode of attack and defence upon nature, and would survive as long as any life capable of affording subsistence survived, without any modification but brain modification. But he would survive only in one of his lowest and most hardy forms. Life would not be worth living to the highest, the finest, the most evolved and cultured products of the essentially different conditions precedent. He would continue as a hyperborean, and if at any subsequent time in the far distant future better conditions supervened, and intelligent life again multiplied from any germ left, he might be discovered in some almost inaccessible retreat, so modified as to be incapable of resuming the habits of his ancestors, and like the whale, the walrus, the seal, and the manatee, stand as a monumental survival and witness of the excessive ordeal of the material conditions through which he had passed.

The above paper was read before the Anthropological Society of Washington March 15, 1884, and was followed by a discussion in which Messrs. L. F. WARD, J. C. WELLING, CYRUS THOMAS, and O. T. MASON participated. This discussion, together with a brief abstract of the paper, is given in Vol. III of the Transactions of the Society, p. 51.